

slightly oval shape and include any number of activation areas, possibly extending over different angular segments.

[0051] Cascading pie menus can also be provided whereby from activation area 24, a single pop-up pie menu 30 will appear with multiple activation areas 32 and by touching one of the activation areas 32, another pop-up pie menu will appear having the same circular shape as pie menu 30 or a different shape and form.

[0052] For example, referring to FIG. 3A, pie menu 30 has four activation areas 32 shaped as equally spaced sector segments. Touching any one of the activation areas 32 causes a cascaded menu to appear in an extended portion of the respective sector. If the "Grayscale" activation area is touched, for instance, the cascaded menu 34 appears, containing in this case two activation areas 36 which are preferably spaced equidistant from the center point of pie menu 30. Similarly, if activation area 36 labeled "2D" is subsequently touched, another cascaded menu 38 appears, again with two activation areas 40, extending from the activation area 36 labeled "2D". Activation areas 40 are preferably spaced equidistant from the center point of pie menu 30. Although this example shows a particular number and pattern of activation areas 32, 36, 40 in cascaded menus 30, 34, 38 (four, then two, then two), it will be understood by those skilled in the art that any number of cascades and any number of segments within each cascade level could be implemented, subject to the constraints of limited display area and minimum font size for the labels. Although labels for the activation areas 32, 36, 40 are shown in this example, other indicators of function could be used instead, such as graphic images, colors, or shapes. After touching the desired activation area(s) 32, 36, 40 in one or more cascaded menu 30, 34, 38, the user may confirm the final choice of activation area 32, 36, 40, and thereby the system function desired, by any of various means including but not limited to waiting for a predetermined "quiet" period to expire with no further selections, or by double-touching (i.e., quickly touching twice) the desired activation area, or by touching the center of the pie menu 30 at activation area 24, where the graphic displayed therein may have been changed by computer 16 after the first selection of an activation area 32, replacing the initially displayed "X" graphic offering cancellation of the selection to a "check" graphic offering confirmation of the final selection.

[0053] Alternatively, other types of cascading, segmented activation areas or pop-up menus can appear. For example, referring now to FIG. 3B, a pie menu 42 with trapezoidal activation areas 44 can be used, enabling the formation of a cascade submenu 46 defining a set of segmented polygons constituting activation areas 48. The center points of the activation areas 44, 48 may be possibly equidistant from a common point on the touchscreen. In each cascaded submenu 46, one of the polygons 48 abuts the selected activation area 44 in the parent pie menu 42. Preferably, this abutting polygon 48 contains the dominant choice in the cascaded submenu 46. In FIG. 3B, the cascaded submenu 46 for the "Flow" activation area of the parent pie menu 42 is displayed. The dominant choice on the cascaded submenu 46 is "Gain", and its activation area 48 abuts the "Flow" activation area, because selecting "Gain" after selecting "Flow" will result in the least movement and effort for the user.

[0054] Turning now to FIGS. 4A, 4B and 4C, an activation area 50 representing a series of control values is exemplified. Activation area 50, as shown in this example, controls the ultrasound TGC function, and consists of an elongated rect-

angle with a border drawn to define the region in which the user's touch will have an effect on the TGC control profile. The activation area 50 is first displayed, preferably, by means of touching another activation area 22 labeled "TGC". The existing TGC profile is initially graphed in the activation area 50, using profile curve 52 as shown in FIG. 4A (the solid line). The profile curve 52 represents the relative amount of receive gain along the ultrasound scan lines in the image as a function of scan depth, where the starting scan depth is at the top of the profile and deeper depths are lower on the profile. Where the profile 52 bends to the right hand side of the activation area 50, the relative gain in the scan lines is greater. Thus, minimum gain is at the left side of the activation area 50. This arrangement matches the typical layout of hard TGC controls on a conventional ultrasound scanning system.

[0055] The user may change the TGC profile by touching continuously in the activation area 50 and drawing a new touch path 54 with a finger, stylus or the like. In this example, the TGC control preferably changes gradually in response to repetitions of touch path 54. An exemplary sequence of two touch paths 54, 58 are shown in FIGS. 4A-4C. In FIG. 4A, the touch path 54 decreases gain around the midfield depth, as indicated by the leftward bend of the path around the middle of activation area 50. The response of the system is shown in FIG. 4B, where computer 16 has redrawn the profile curve in response to the touch path 54 shown in FIG. 4A. The revised TGC profile 56 has a bend to the left around the mid-field, but not as distinct and extensive as the touch path 54, reflecting the gradual, averaging algorithm used to make changes to the profile. An exemplifying algorithm averages the values collected from the touch path 54 with the values stored in the previous TGC profile curve 52. This averaging facilitates the user's ability to see the changes he is making without obscuring them with his finger, and also allows the user to make fine changes by repeated gestures (touch paths) within the small, narrow activation area 50. Both of these advantages suit the needs of the compact visual field 20.

[0056] In this example, and referring to FIG. 4B, the user then draws a second touch path 58, which adjusts the TGC profile only near the deepest depth, with a relatively short touch path. The user begins touch path 58 near the bottom of the activation area 50. The computer 16 therefore makes no change to TGC profile curve 56 in the shallower depths. FIG. 4C shows the resulting TGC profile curve 60, accumulating changes from both preceding touch paths 54, 58. If the user is satisfied with the TGC profile shape, he leaves the activation area 50 untouched for a short quiet time (typically turning to some other task), and computer 16 automatically removes the activation area 50 from the visual field 20.

[0057] Using activation areas 22, 24, 26 and the described variations thereof, all of the possible control functions of the ultrasound system 10 can be implemented as virtual controls on the touchscreen 18.

[0058] The ultrasound system 10 described above can be combined with a display of real-time three-dimensional ultrasound images wherein the images are rendered as either semi-transparent volumes or as multiple planes oriented in their true spatial positions with respect to each other. The latter image format is exemplified by the test pattern 62 of three superimposed images planes shown in the center of the visual field 20 on the touchscreen 18 in FIG. 5. Touchscreen 18 allows manipulation of specific three-dimensional parameters, such as the orientation of the image, the degree of opacity, etc., via the activation areas 22 which are labeled